Getting Started with
HFSS™
An RCS Test Model

ANSYS, Inc.
275 Technology Drive
Canonsburg, PA 15317
USA
Tel: (+1) 724-746-3304
Fax: (+1) 724-514-9494
General Information: AnsoftInfo@ansys.com
Technical Support: AnsoftTechSupport@ansys.com

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New editions of this manual incorporate all material updated since the previous edition. The manual printing date, which indicates the manual's current edition, changes when a new edition is printed. Minor corrections and updates that are incorporated at reprint do not cause the date to change.

Update packages may be issued between editions and contain additional and/or replacement pages to be merged into the manual by the user. Pages that are rearranged due to changes on a previous page are not considered to be revised.

Edition	Date	Software Version
1	May 2003	9
2	June 2005	10
3	June 2007	11
4	Sept 2009	12
5	October 2010	13.0
6	August 2011	14.0

Conventions Used in this Guide

Please take a moment to review how instructions and other useful information are presented in this guide.

- Procedures are presented as numbered lists. A single bullet indicates that the procedure has only one step.
- Bold type is used for the following:

  - Keyboard entries that should be typed in their entirety exactly as shown. For example, “**copy file1**” means to type the word **copy**, to type a space, and then to type **file1**.

  - On-screen prompts and messages, names of options and text boxes, and menu commands. Menu commands are often separated by carats. For example, click **HFSS>Excitations>Assign>Wave Port**.

  - Labeled keys on the computer keyboard. For example, “Press **Enter**” means to press the key labeled **Enter**.
- Italic type is used for the following:

  - Emphasis.

  - The titles of publications.

  - Keyboard entries when a name or a variable must be typed in place of the words in italics. For example, “**copy** *file name*” means to type the word **copy**, to type a space, and then to type a file name.
- The plus sign (+) is used between keyboard keys to indicate that you should press the keys at the same time. For example, “Press **Shift+F1**” means to press the **Shift** key and the **F1** key at the same time.
- Toolbar buttons serve as shortcuts for executing commands. Toolbar buttons are displayed after the command they execute. For example,

  “On the **Draw** menu, click **Line**  ” means that you can click the Draw Line toolbar button to execute the **Line** command.

Getting Help

ANSYS Technical Support

To contact ANSYS technical support staff in your geographical area, please log on to the ANSYS corporate website, https://www1.ansys.com. You can also contact your ANSYS account manager in order to obtain this information.

All ANSYS software files are ASCII text and can be sent conveniently by e-mail. When reporting difficulties, it is extremely helpful to include very specific information about what steps were taken or what stages the simulation reached, including software files as applicable. This allows more rapid and effective debugging.

Help Menu

To access online help from the HFSS menu bar, click **Help** and select from the menu:

- **Contents** - click here to open the contents of the online help.
- **Seach** - click here to open the search function of the online help.
- **Index** - click here to open the index of the online help.

Context-Sensitive Help

To access online help from the HFSS user interface, do one of the following:

- To open a help topic about a specific HFSS menu command, press **Shift**+**F1**, and then click the command or toolbar icon.
- To open a help topic about a specific HFSS dialog box, open the dialog box, and then press **F1**.

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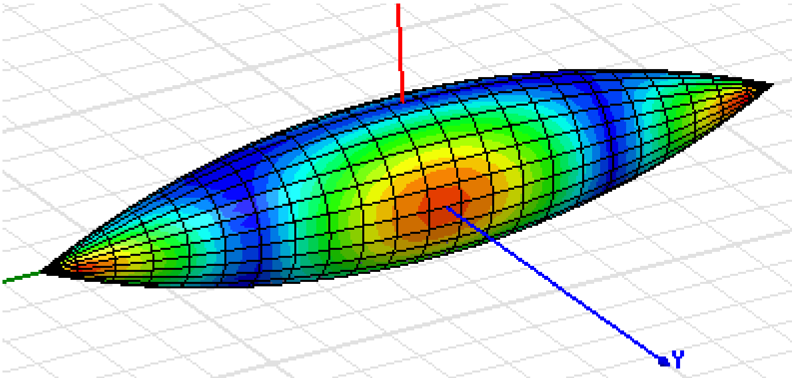
HFSS-IE: RCS Test Model

This example looks at the scattering from a standard RCS test model, the ogive.



We will look at the scattering from a conducting ogive with a length of 10" and a half angle of 22.6° = 0.3948 radians. The ogive lies with its axis along the x axis. The equation that defines this model is:

F(x) = sqrt{1 - [(x/5.0)*sin(22.6°)]^2} - cos(22.6°)
y = F(x)*cos(φ)/[1-cos(22.6°)]
z = F(x)*sin(φ)/[1-cos(22.6°)]

assuming that the x, y, z are defined in inches.

Creating the Model

Creating this model is very straightforward. We will create an equation based curve in the x-y plane and then sweep around the x axis to create the 3D solid.

1 Open a project and insert a new HFSS-IE design.

The default units can be changed to inches (in) if you desire, but we will ensure the proper units when defining the model so you can leave it at the default of mm.

2 Click **Draw>Equation Based Curve**.

The **Equation Based Curve** dialog opens.

Let x = the parametric variable (=_t). In the x-y plane z = 0 so the equation for y is:

```
y = (sqrt(1-(_t*sin(.3948)/5)^2) - cos(0.3948)
```

The angles are entered in radians and to insure the units are handled properly we multiply each nonzero term (x and y) by the quantity: (1in). So in the **Equation Based Curve** dialog, you enter the equations as follows:

X(_t) = _t*(1in)

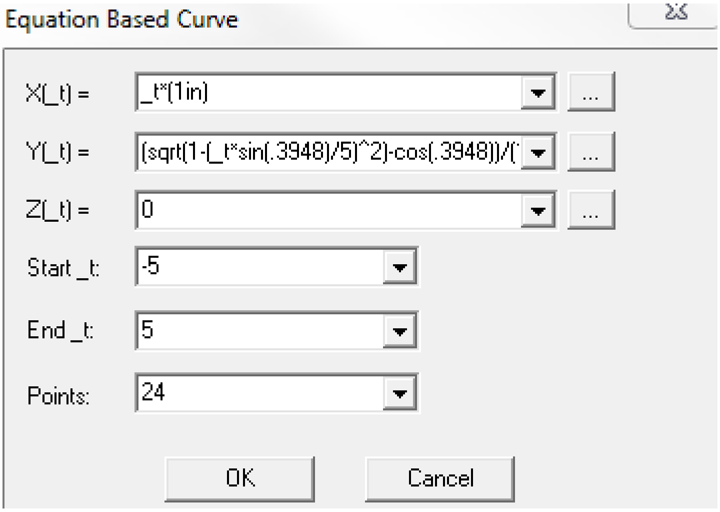
Y(_t) = (sqrt(1-(_t*sin(.3948)/5)^2)-cos(.3948))/(1-cos(.3948))*(1in))

Z(_t) = 0

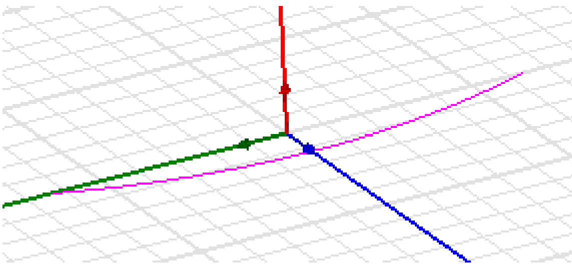
Start _t= -5

End _t= 5

Number of Points = 24



When you click OK to close the dialog and execute the command, you should see a line like the following:



Look in the **History** tree under Lines and Equation Curve1 and double-click on CreateEquationCurve. This lets you view the command **Properties** window which includes the setup shown, with the Value column expanded for com-pete viewing.

Name	Value	Unit	Evaluated Value
Command	CreateEquationCurve		
Coordinate Sys...	Global		
X(_t)	_t*(1in)		******
Y(_t)	(sqrt(1-(_t*sin(.3948)/5)^2)-cos(.3948))/(1-cos(.3948))*(1in))		******
Z(_t)	0		0
Start _t	-5		-5
End _t	5		5
Number of Poi...	24		24

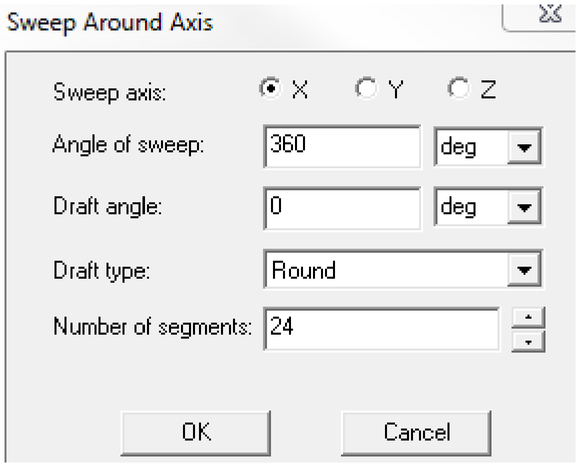
If the line does not display as expected, you can edit the value fields here.

There are no curvilinear elements in HFSS-IE so all curved surfaces are approximated with segmented models. With that in mind it is recommended you enter the desired number of segments in the Number of Points box here. This allows you to easily adjust the model later if so desired. What will result is a polyline called EquationCurve1.

3 Select EquationCurve1 and then click **Draw>Sweep >Around Axis**.

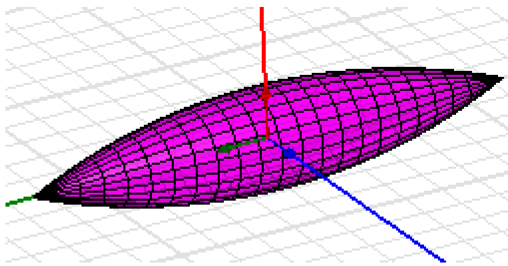
The **Sweep Around Axis** dialog displays.

4 In the Sweep Around Axis dialog select X axis, Angle of sweep = 360, and Number of segments = 24 as shown.



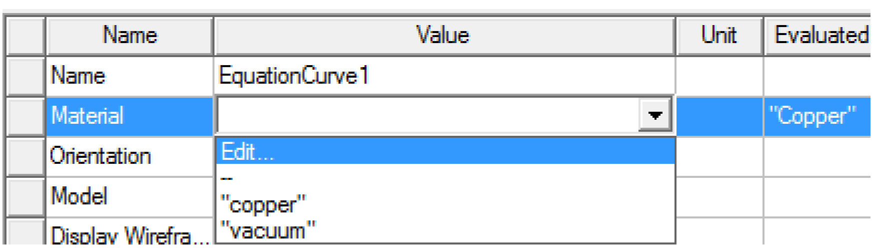
5 Click OK

The result then should be a solid that is the desired ogive:



The default material assigned to this object is likely copper. Typically these shapes are fabricated using aluminum.

6 Select the ogive object and in the **Properties** window click on the word copper in the Material box and select edit.



This opens the Materials selection dialog.

7. In the Material selection window chose aluminum and click OK.

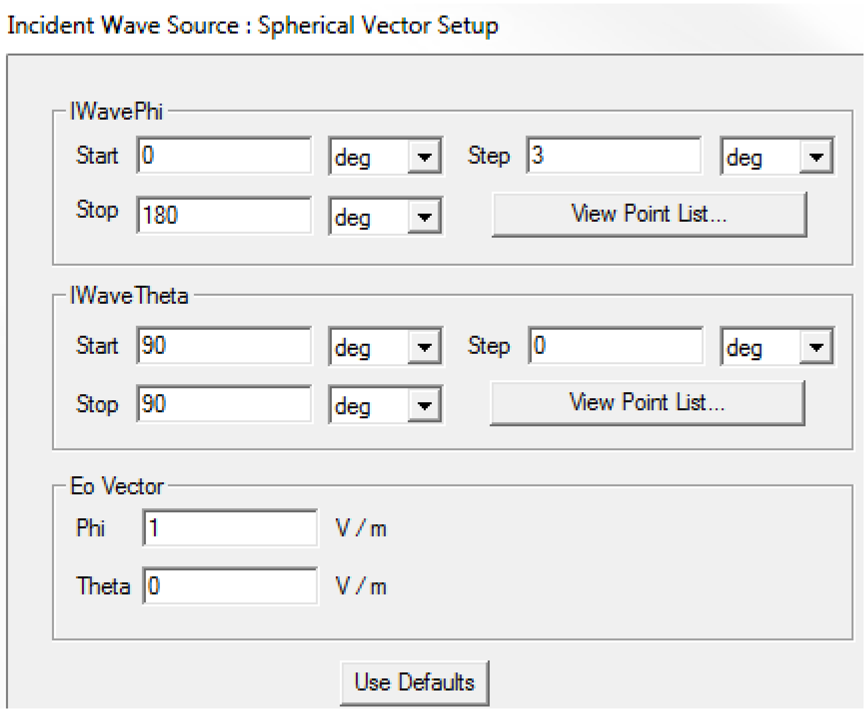
The model is finished. It has no airbox to worry about so the model, material and boundary setups are complete.

Add an Incident Plane Wave

We next need to add the source in this case the incident plane wave. We will compute the monostatic RCS in a the x-y plane. Since it is monostatic RCS we will need to include many incident angles. For the scattering computed here we should get a clean response if we solve every 3°.

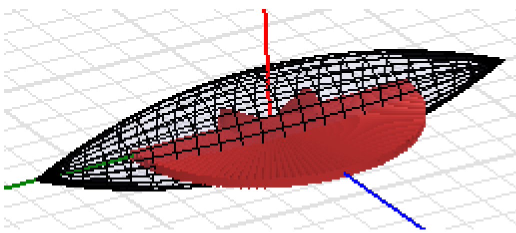
1. With the model not selected, right click in the model window select **Assign Excitation>Incident Wave>Plane Incident Wave** from the short cut menu.

   The **Incident Wave Source: General Data** dialog opens.
2. In the **General Data** dialog select Spherical for Format and leave the Zero Phase Position as (0,0,0).
3. Click **Next** and in the Spherical Vector Setup window, for Iwave phi Start as 0, Stop as180 and Step as 3.
4. For IWave theta select Start as 90, Stop as 90 and Step as 0.
5. Last set the magnitude for Eo Vector Phi =1 and E theta = 0.



6 Click **Next** and then **Finish** and the excitation is defined.

The Incident Plane wave appears under Excitations in the Project tree. If you select the Incident Plane wave, the Modeler window shows it as follows.

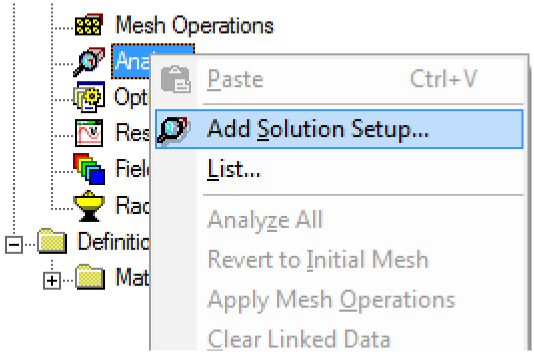


This will solve for the response due to incident planes waves that are incident in the θ=90°and for φ= 0 to 180° for 61 values. The polarization is φ directed so we will be solving for the HH monostatic RCS.

Adding the Solution Setup

The last step is to add the solution setup.

1. Right click on **Analysis** under the IEDesign in the Project Manager window and select **Add Solution Setup**.



   This opens the **Solution Setup** dialog.

2. In the **General** tab change the Frequency to 1.18 GHZ. Leave the rest at its default values.
3. That is all that is needed. Click OK now or if you desire you can look at the **Options** tab where you should see that the default lambda refinement is 0.25 (=$\lambda_0/4$).

The Ogive project setup is compete.

Run the Simulation

To run the simulation:

1. Right-click on the Setup just created in the Project Manager window and select **Analyze**.
2. It should first ask you to save the project by asking a project name - enter anything you desire. Once the project has been saved it will simulate and should solve quickly in 2 passes.

Plotting the Current

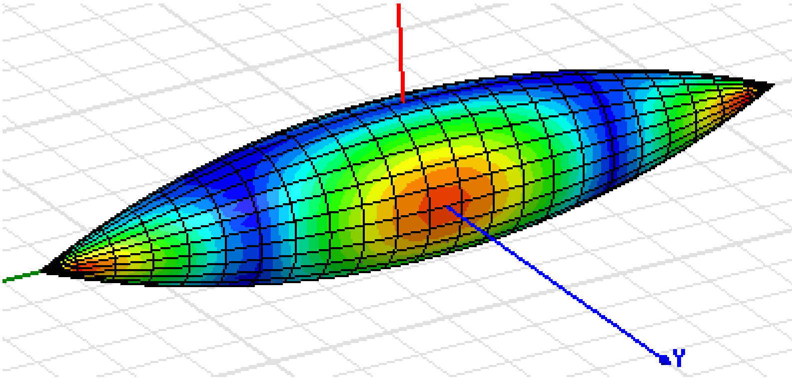
To view the current on the ogive:

1. Select the ogive in the model window and right click and go to: **Fields>J>Mag_J**.

   This opens the **Create Field Plot** dialog.

2 Click on Done.

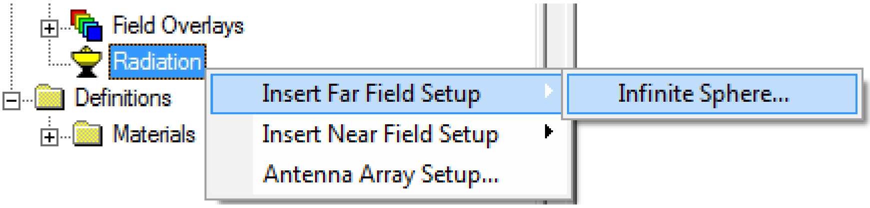
You will see the induced current for φ=0° incident angle:



Plotting the RCS

To plot the RCS you first must enter a Far Field setup - the same as for HFSS. We will create a far field setup with only 1 φ angle = 0° and one θ angle = 90°. We will be plotting the monostatic RCS and so will be plotting against the incident phi angle and not the observation angles defined here. So we only need one angle for each.

1 Right click on Radiation in the Project tree of the Project Manager window and select **Insert Far Field Setup>Infinite Sphere…**

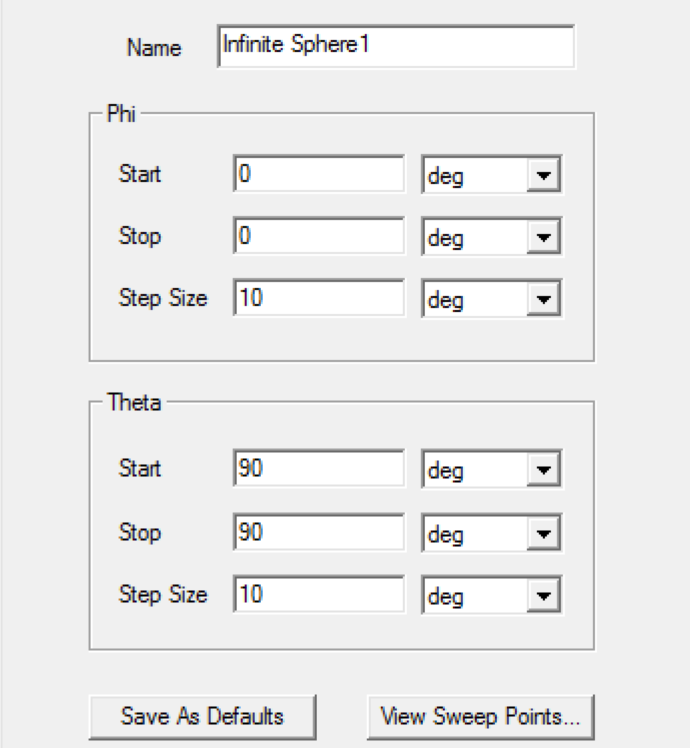


The **Far Field Radiation Sphere Setup** dialog opens.

2 Enter Start and Stop for Phi as 0 and the step size 10.

3 Enter Start and Stop for Theta as 90 and the Step size 10.

You should have the following:



4 Click OK.

   This closes the dialog and creates InfiniteSphere1 under Radiation in the Project tree.

5 To create the plots, right click on Results in the Project tree and click **Create Far Fields Report>Rectangular Plot**.

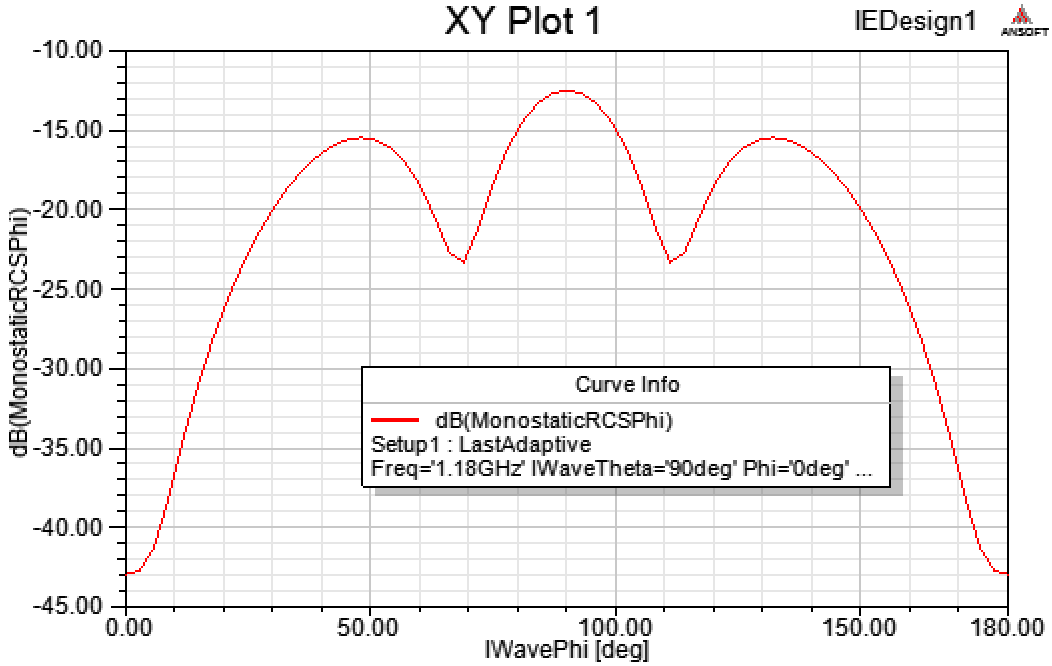
   The **Reports** dialog opens.

6 Specify the following: for Category: Monostatic RCS; for Quantity: MonostaticRCSPhi; and for Function: dB.

7 Change the Primary Sweep from Theta to IWavePhi (we want to plot the RCS vs. the incident phi angles).

8 Click **New Report**.

The resulting plot should resemble this:



This is the HH monostatic RCS pattern for the standard ogive at 1.18GHZ.

Again these post processing functions are the same as for HFSS (except you plot shade plots of J not E). You may want to take some time and work with the post processor. For example it is interesting to create an animation of the current shade plot vs. incident angle.